

Saturated Hydraulic Conductivity as Parameter in Modeling Applications - Comparison of Determination Methods



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Basic Reflections

Saturated hydraulic conductivity, K_s , is a broadly used physical soil parameter. Several different methods for determination of K_s are applied, no standard method is established. K_s is a key parameter in functions to describe hydraulic soil properties.

Methods

Three different methods were used to derive a value for K_s :

- Infiltrometer:** Hood Infiltrometer after Schwärzel and Punzel (2007)
3 tension steps between $\Psi = 0$ and max. 7 cm,
diameter of infiltration area (circular): 12.4 cm.
- Falling head:** lab method with falling head,
undisturbed soil core in steel ring, $d=8.4\text{cm}$, $h=5\text{cm}$, $V=250\text{ccm}$.
- Evaporation method:** extended evaporation method after Schindler et al. (2010) by use of HYPROP®-devices (www.ums-muc.de), same soil core used as for falling head method.

Determination of K_s : falling head method measures directly; Infiltrometer and evaporation method require calculation by model fitting, herein used was the function after Gardner (1958; Eq.(1) - used symbols: $K(\Psi)$ =measured unsaturated conductivity, Ψ =matrix potential, α =function parameter)¹.

$$K(\psi) = K_s \exp(\alpha \psi) \quad (1)$$

Materials

Soil samples from arable land, 3 sites in Lower Austria, some basic data in table 1. Soil cores taken on the surface without hammering, litter or crusts were carefully removed. Measurement points located between crop rows.

Tab.1: Study site data; MAP=mean annual precipitation, SOC=Soil Organic Carbon; textural soil type classified after ÖNORM L1050

	Crop 2016	soil type (texture)	soil type	MAP	SOC	n
Obersiebenbrunn	winter wheat	sandy loam	Chernozem	520 mm	1 - 2%	42
Hollabrunn	sunflower	loamy silt	Chernozem	519 mm	1 - 2%	69
Pyhra	winter ray / meadow	sandy loam	Pseudogley	860 mm	1 - 2%	8

Conclusions

The reason for low values from evaporation method might lie in the measurement range for conductivity by evaporation method ($pF > 1-1.5$) which leads to deviations due to the bimodal character of pore size distribution and soil hydraulic properties, respectively².

For further use in modeling applications K_s should be determined by appropriate methods for saturated or near-saturated conditions like infiltrometry or K_s -lab experiments in addition to evaporation methods for drier conditions.

References

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Objective of the study

Evaluate different approaches to determine K_s for the use as a parameter in the formal description of hydraulic soil properties which is subsequently applied in modeling soil water dynamics.

Results

Results from evaporation method are in average nearly 3 orders of magnitude lower than from falling head and infiltrometer method (Fig.1 and 2). Wilcoxon signed-rank tests ($\alpha=0.05$) stated significant differences between locations of all three result data sets.

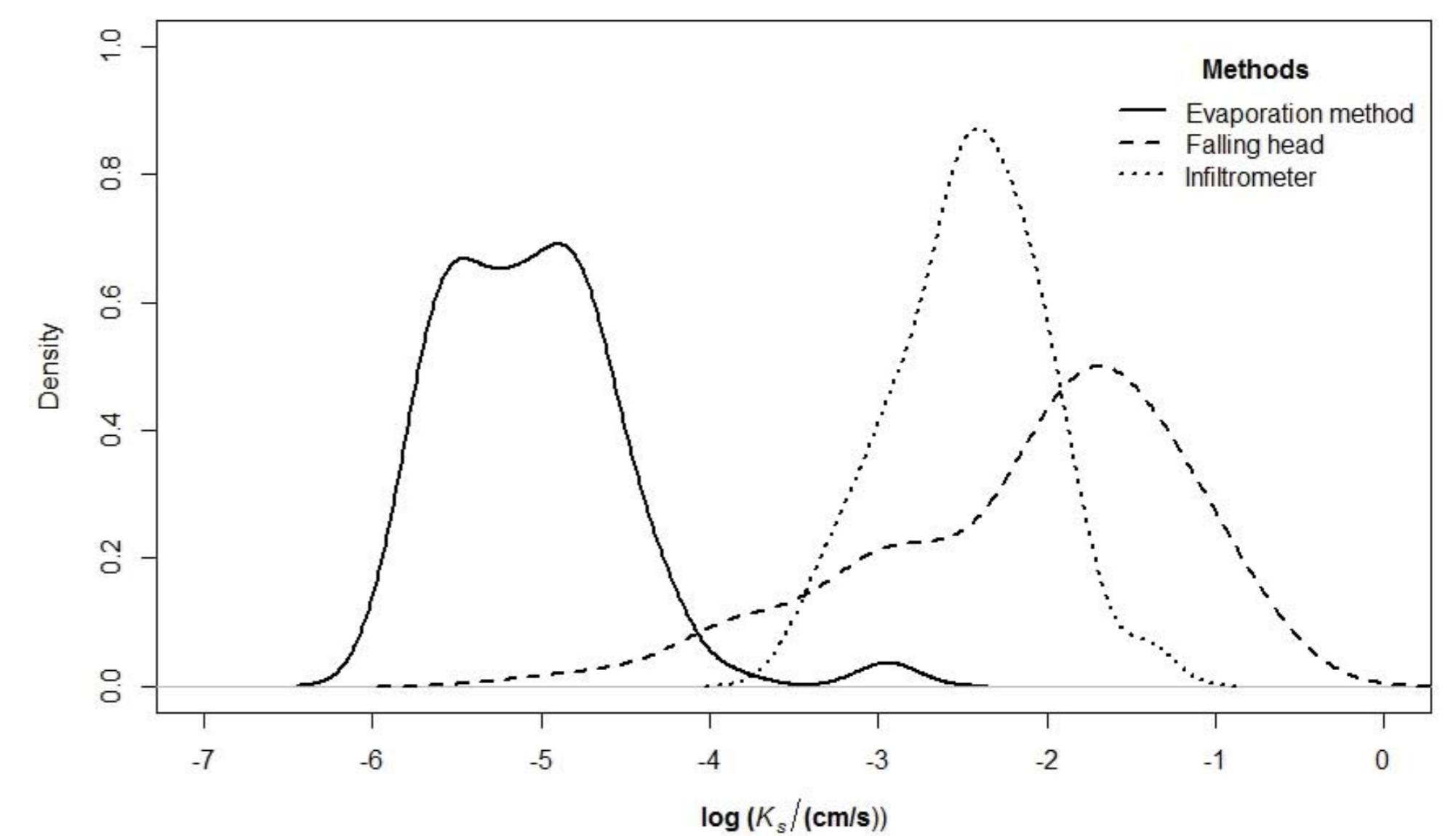


Fig.1: empirical density functions of K_s for the three used methods, $n=119$

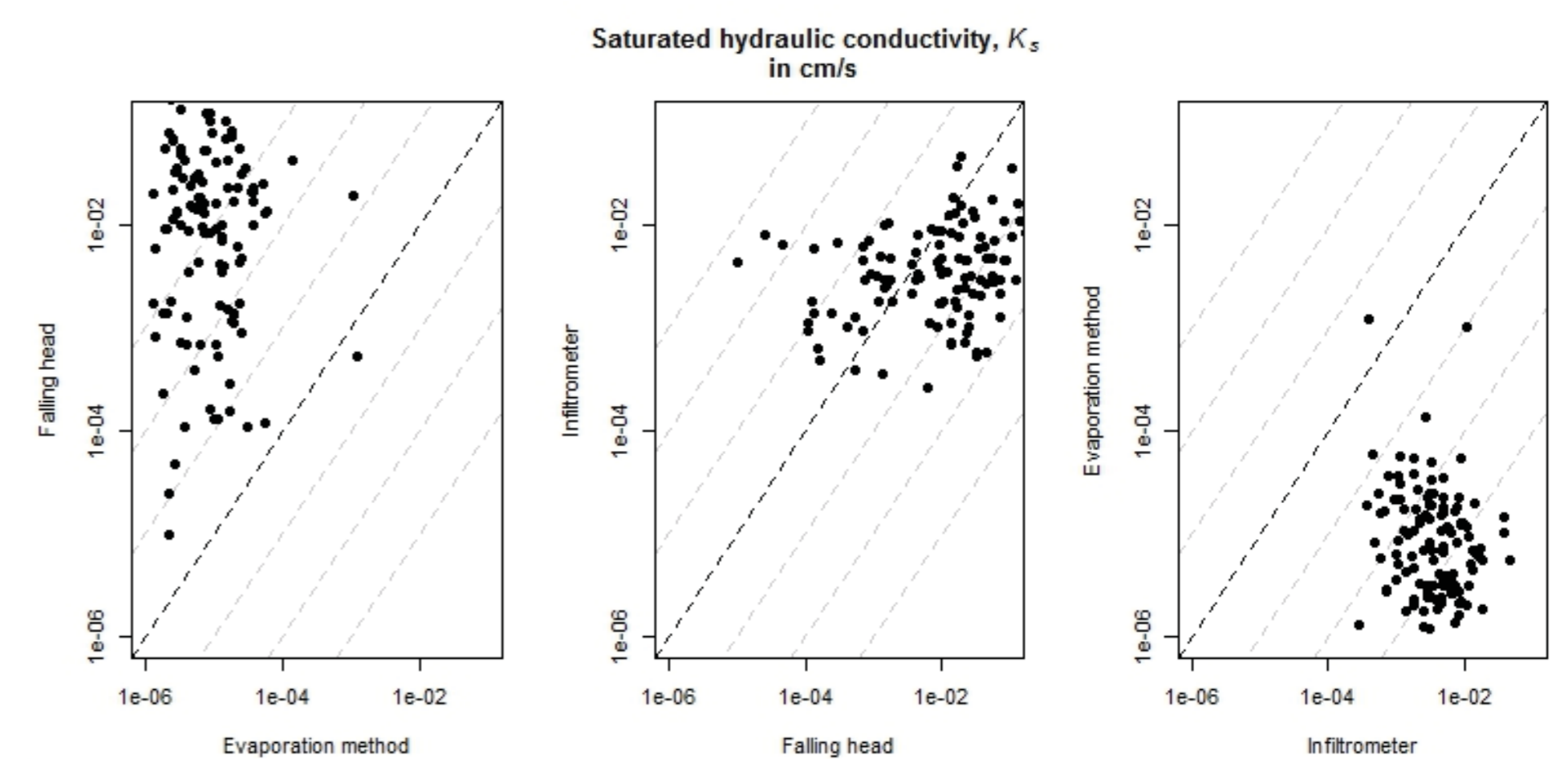


Fig.2: comparison of measured values per method; strong dashed line is $x=y$, gray dashed lines visualize residuals of one order of magnitude each, $n=119$

For the very interested

This study is part of the work on an international research project which focuses on the formal description of management-driven alterations of hydraulic soil properties of arable soils. Collection of a comprehensive data set on field sites in Eastern Austria and Eastern Germany builds the basis and different tillage strategies as well as land-use changes (e.g. afforestations) are examined.

¹Why did we choose the Gardner-model? Due to its simplicity with only one more fitting parameter in addition to K_s and because it is used as somehow a standard for tension infiltration experiments. Original literature says it is applicable in a small but undefined range of pF . Another model (e.g. Mualem) would be maybe more appropriate for the full range but as this is a comparison study, we decided for Gardner.

²Soils in natural environments often show a distinct differentiation between so-called macro- and micropores. Hence, the pore size distribution has two modes, one in the range of secondary macropores which are built by soil organisms or physical processes. The second one is a result of the soil texture and represents the most frequent size of primary micropores (e.g. Blum, 2007).

As the project runs until 2018, we will also extend this study on additional data. Hence, if you have similar data and no resources for such an analysis, we would be happy to cooperate. Contact data see above or talk to the guy next to this poster.